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(54) Deflector for marine data acquisition system

Deflektor für Marinedatenerfassungssystem

Déflecteur pour système d'acquisition de données en mer

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Description

BACKGROUND

TECHNICAL FIELD

[0001] Embodiments of the subject matter disclosed herein generally relate to devices and systems used for marine exploration and, more particularly, to deflectors attached to cables that carry seismic instrumentation.

DISCUSSION OF THE BACKGROUND

[0002] Marine data acquisition and processing generate a profile (image) of a geophysical structure under the seafloor. While this profile does not provide an accurate location of oil and gas reservoirs, it suggests, to those trained in the field, the presence or absence of these reservoirs. In order to obtain a high-resolution image of the structure under the seafloor, plural techniques and devices are employed to maintain the data acquisition geometry while scanning the targeted area.

[0003] In marine exploration, waves (such as, but not limited to, seismic waves) are directed toward the seabed, and waves reflected back to receivers close to the water surface are used to extract information about the structure and nature of the rock layers underneath the seabed. A vessel usually tows a series of cables connected to a seismic source and/or a streamer that includes the receivers. The vessel tows the cables along a specified path to scan the targeted area. Arranging and maintaining the configuration of these cables (e.g., with minimal drag, the cables remaining at their assigned depth and lateral offset) is desirable. One of the devices employed in order to arrange and maintain the configuration of these cables is a deflector. The deflector is attached to a towing cable and provides a lift force to the cable while towed through the water, to maintain depth and/or lateral separation among the towing cables.

Patent application GB 2 223 728 discloses a hydrodynamic depressor comprising a flat swept wing. Patent US 6 820 568 discloses a hydrofoil apparatus for inclusion in a towed arrangement. Patent application US 5 000 110 discloses a hydrodynamic equipment employed to maintain an object which is being towed through water, at a predetermined depth. Patent application US 2 980 052 discloses a paravane having cambered hydrofoils with high lift-to-drag and lift-to weight ratios. Patent application US 5 263 430 discloses an aquatic amusement device which is a tethered hydroplane board having a pair of planar V-shaped members arranged perpendicularly.

[0004] Figure 1 illustrates a prior art deflector 10 attached to a towing cable 20. The deflector 10 has a flat, rectangular-shaped body 12 and may have ballast bodies 14 and 16 (also known as pods) at ends of the body 12. A top ballast body 14 is lighter than a bottom ballast body 16 to move the gravity center of the deflector 10 below a buoyancy center thereof. The deflector 10 may also have a slot 18 along the body 12 to increase the stalling angle. The length of the deflector may be around 2.5 m. The deflector 10 is attached to the cable 20 around a middle area of the deflector 10.

[0005] A problem with the prior art deflector is that its angular stability is low, that is, if it rotates (e.g., due to currents) around the towing position, the deflector does not return to the intended position, and, therefore, instead of providing a lift force, drags down the towing cable. Figures 2A and 2B illustrate this problem.

[0006] Thus, it is desired to produce a deflector that has better angular stability such that if it rotates around the towing position, it develops a returning torque that returns the deflector to the intended position.

SUMMARY

[0007] One objective achieved in some of the embodiments described in this application is to provide a deflector with improved angular stability for marine survey (i.e., data acquisition) systems. That is, deflectors are configured to develop a restoring torque opposing deviations (pitch, roll and yaw) of the deflector from an intended position.

[0008] According to one exemplary embodiment, there is a deflector according to claim 1.

[0009] According to another exemplary embodiment, there is a marine data acquisition system according to claim 11.

[0010] According to another exemplary embodiment, there is a method of controlling the position of one or more components of a marine data acquisition system according to claim 15.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate one or more embodiments and, together with the description, explain these embodiments. In the drawings:

Figure 1 is a schematic diagram of a prior art deflector

Figures 2A and 2B illustrate an unintended roll and yaw of a prior art deflector;

Figure 3 is a schematic diagram of a marine data acquisition system according to an exemplary embodiments;

[0012] According to another exemplary embodiment, there is a method of controlling the position of one or more components of a marine data acquisition system. The method includes attaching at least one deflector to at least one towing cable configured to be towed behind a vessel to carry marine survey instrumentation. The deflector has a wing body including a first part joined to a second part to form a swept-back-wing shape, the first

part and the second part being substantially coplanar. A first straight line stretching along at least a portion of a front edge of the first part makes a first angle with a second straight line stretching along at least a portion of a front edge of the second part. A third straight line stretching along at least a portion of a trailing edge of the first part makes a second angle with a fourth straight line stretching along at least a portion of a trailing edge of the second part, the first angle and the second angle being non-zero angles. The method further includes deploying the towing cable behind the vessel according to a predetermined marine data acquisition geometry.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate one or more embodiments and, together with the description, explain these embodiments. In the drawings:

Figure 1 is a schematic diagram of a conventional deflector;

Figures 2A and 2B illustrate an unintended roll and yaw of a conventional deflector;

Figure 3 is a schematic diagram of a marine data acquisition system according to an exemplary embodiment;

Figure 4 is a deflector according to an exemplary embodiment;

Figure 5 is a deflector according to another exemplary embodiment;

Figure 6 is a graph illustrating pitch torque versus pitch angle for various deflectors including exemplary embodiments;

Figure 7 is a graph illustrating yaw torque versus yaw angle for various deflectors including exemplary embodiments; and

Figure 8 is a flowchart of a method for towing a source array according to an exemplary embodiment.

DETAILED DESCRIPTION

[0014] The following description of the exemplary embodiments refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements. The following detailed description does not limit the invention. Instead, the scope of the invention is defined by the appended claims. The following embodiments are discussed, for simplicity, with regard to the terminology and structure of a marine survey data acquisition system having one or more cables towed by a vessel. However, the embodiments to be discussed next are not limited to this structure, but they may be applied to other situations in which cables are towed in water at a predetermined depth.

[0015] Reference throughout the specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with an embodiment is included in at least one embodiment of the subject matter disclosed. Thus, the appearance of the phrases "in one embodiment" or "in an embodiment" in various places throughout the specification is not necessarily referring to the same embodiment. Further, the particular features, structures or characteristics may be combined in any suitable manner in one or more embodiments.

[0016] Figure 3 is a schematic diagram of a marine data acquisition system 300 (bird's eye view) according to an exemplary embodiment of the invention. A vessel 310 tows plural lead-in cables. The lead-in cables 320 are configured to be deployed according to a predetermined geometry so that streamers 340 remain substantially parallel at predetermined distances there-between. Hydrophones or other receivers (not shown) along the streamers 340 record reflected seismic waves following a shot of a seismic source 330. One or more deflectors may be attached to the lead-in cables 320. Figure 3 illustrates a deflector 350 attached to each of the lead-in cables 320. However, depending on size and placement of the deflector and presence of separation ropes tied between the cables, a deflector may have impact on plural streamers, i.e., fewer deflectors may be deployed. Alternatively, plural deflectors may be mounted along a single cable. The number of streamers illustrated in Figure 3 is exemplary and not intended to be limiting.

[0017] A deflector 400 ("wide V-shape deflector") according to an exemplary embodiment of the invention is illustrated in Figure 4. The deflector 400 has a wing body including a first part 410 joined to a second part 420 to form a swept-back-wing shape. The first part 410 and the second part 420 may be manufactured as a single piece. In one application, the first part is manufactured separately from the second part and it is attached to the second part by using known mechanisms, e.g., welding, gluing, bolts, etc. In one application, the first part 410 and the second part 420 are substantially flat and coplanar.The first and second part may be symmetrical relative to a joining axis 430.

[0018] A first straight line along a front edge 412 of the first part 410 makes a first angle α_1 with a second straight line along a front edge 422 of the second part 420. In one application, the first angle α_1 is a non-zero angle. A third straight line along a trailing edge 414 of the first part 410 makes a second angle α_2 with a fourth straight line along a trailing edge 424 of the second part 420. In one application, the second angle α_2 is a non-zero angle. The front edge is defined as the edge of the deflector (or wing) that is first along a moving direction (breaks the water) and the trailing edge is the last edge along the moving direction.

[0019] In one application, the first angle α_1 and the second angle α_2 may be substantially equal. The second angle α_2 is preferably at least equal to the first angle α_1. In another application, the first angle is between 10° and 30°, preferably between 15° and 25°.

[0020] The first part 410 may have a first slot 416 ex-

tending from an end where the first part 410 is joined to the second part 420 toward an opposite end of the first part 410. The second part 420 may also have a second slot 426 extending from an end where the second part is joined to the first part to an opposite end of the second part. The first slot 416 and the second slot 426 may also be symmetrical relative to the joining axis 430. The slots 416 and 426 allow water to pass through the first and second parts. This action improves the stability of the deflector, e.g., reduces stalling.

[0021] The deflector 400 may include a first ballast body (or "pod") 418 located at an end of the first part 410 opposite to the joining axis 430, and a second ballast body 428 located at an end of the second part 420 opposite to the joining axis 430. The first ballast body 418 and the second ballast body 428 may have a shape configured to have low fluid friction when the body moves substantially parallel to the joining axis. In one application, the first ballast body 418 is substantially lighter than the second ballast body 428. For example, the first ballast body 418 may weigh between 10% and 35% of the second ballast body 428. In one application, the deflector is neutrally buoyant and the ballast is about 40% of the deflector's weight. The deflector may be made of various materials, e.g., composite, plastic, metal, or a combination thereof.

[0022] A deflector 500 ("rounded wide V-shape deflector") according to another exemplary embodiment of the invention is illustrated in Figure 5. The deflector 500 is similar to deflector 400, having a wing body including a first part 510 joined to a second part
520 to form a swept-back-wing shape. The first part 510 and the second part 520 are substantially flat and coplanar. The first and second part may be symmetrical relative to a joining axis 530. A first straight line extends along a part (i.e., from ballast body 518 to point A, for more than 50% of the length thereof to ensure stability) of a front edge 512 of the first part 510. A second line extends along a part (i.e., from ballast body 528 to point B, for more than 50% of the length thereof) of a front edge 522 of the second part 520. The first line makes a first angle $\alpha 1$ with the second straight line. The sides of the first angle $\alpha 1$ are the first and second straight lines. In this respect, it is noted that Figure 5 shows the first straight line extending between ballast body 518 and point A and the second straight line extending between the ballast body 528 and point B. The leading edge of the reflector, between points A and B may be curved.

[0023] A third straight line extends along a part (i.e., from ballast body 518 to point C, for more than 50% of the length thereof) of a trailing edge 514 of the first. part 510. A fourth straight line extends along a part (i.e., from ballast body 528 to point D, for more than 50% of the length thereof) of a trailing edge 524 of the second part 520. The third line makes a second angle α_2 with the fourth line. The second angle α_2 may be a non-zero angle. The first angle α_1 and the second angle α_2 have similar characteristics with angles α_1 and α_2 of deflector 400.

[0024] The first straight line and the second straight line of the deflector 500 may be connected via a first curved portion 540. The third straight line and the fourth straight line of the deflector 500 may be connected via a second curved portion 550. The first curved portion 540 may be an arc of a circle (i.e., a portion of the circle's circumference) having a first radius R_1 and the second curved portion 550 may be an arc of a circle having a second radius R_2. The second radius R_2 may be smaller than the first radius R_1. The first and second curved portions may be parameterized curves (i.e., curves described by a mathematical equation) different from a circle, e.g., a part of an ellipse, or parabola, etc.

[0025] The first part 510 may have a first slot 516 extending from an end where the first part is joined to the second part toward an opposite end of the first part. The second part 520 may also have a second slot 526 extending from an end where the second part is joined to the first part to an opposite end of the second part. The first slot 516 and the second slot 526 may also be symmetrical relative to the joining axis 530.

[0026] The deflector 500 may also include a first ballast body 518 located at an end of the first part 510 opposite to the joining axis 530, and a second ballast body 528 located at an end of the second part 520 opposite to the joining axis 530. The first ballast body 518 and the second ballast body 528 may have similar features as the ballast bodies 418 and 428.

[0027] The deflectors are made of materials compatible with service in both a marine environment and onboard (or in deployment or retrieval from) a vessel. For example, the deflectors may be made of metals and alloys such as duplex steel, stainless steel, aluminum, titanium, plastics, and composites such as fiberglass and carbon fibers.

[0028] Tests and simulations have compared angular stability of the conventional deflector and deflectors similar to the ones illustrated in Figures 4 and 5. It has been observed that the pitch and roll effects are strongly correlated.

[0029] Figure 6 is a graph illustrating a pitch torque versus a pitch angle of a deflector, line 610 therein corresponding to the conventional deflector, line 620 corresponding to a deflector similar to the embodiment illustrated in Figure 4 ("wide V-shape") and line 630 corresponding to a deflector similar to the embodiment illustrated in Figure 5 ("rounded wide V-shape"). Additionally, a deflector similar to the wide V-shape deflector but having α_2 angle equal to zero ("V-full wing") and a deflector having a rectangular but twisted wing body (attack angle reduced at extremities) have been tested, the test results being illustrated as lines 640 and 650, respectively. Lines 620 and 630 overlap and show a substantially improved angular stability than the conventional deflector (line 610), because the wide V-shape deflector and the rounded wide V-shape deflector have a higher pitch torque returning the deflector to the intended position. It has

been observed that this angular stability may be improved by increasing a ratio between the weights of the ballast bodies, up to 0.35.

[0030] Figure 7 is a graph illustrating a yaw torque versus a yaw angle of a deflector, line 710 therein corresponding to the prior art deflector, line 720 corresponding to a wide V-shape deflector (i.e., similar to the embodiment illustrated in Figure 4) and line 730 corresponding to a wide rounded V-shape deflector (i.e., similar to the embodiment illustrated in Figure 5). Lines 740 and 750 correspond to a V-full wing deflector and a twisted wing body deflector, respectively.

[0031] These tests and simulations have demonstrated that both the wide V-shape deflector and the rounded wide V-shape deflector have significantly superior angular stability compared to the prior art deflector. The wide V-shape deflector has best angular stability with a minor loss in performance (around 3% smaller lift force). However, the sharp angle in front of this type of deflector creates a stress concentration location and makes it more difficult to handle. Although the rounded wide V-shape deflector is slightly less stable regarding the yaw angle, this type of deflector does not have the stress concentration problem and it is easier to handle and to manufacture.

[0032] A flow diagram of a method 800 of controlling a position of one or more components of a marine data acquisition system according to another exemplary embodiment of the invention is illustrated in Figure 8. The method 800 includes attaching at least one deflector to at least one towing cable configured to be towed behind a vessel while carrying components of the marine data acquisition system, the deflector having a wing body including a first part joined to a second part to form a swept-back-wing shape, the first part and the second part being substantially coplanar, at S810. The method 800 further includes deploying the towing cable behind a vessel according to predetermined marine data acquisition geometry, at S820. The at least
one deflector may be similar to any of the embodiments illustrated in Figure 4 and 5, wherein a first straight line along at least a portion of a front edge of the first part makes a first angle with a second straight line along at least a portion of a front edge of the second part, and a third straight line along at least a portion of a trailing edge of the first part makes a second angle with a fourth straight line along at least a portion of a trailing edge of the second part, the first angle and the second angle being non-zero angles.

[0033] One or more of the exemplary embodiments discussed above are related to deflectors attached to a towing cable of a vessel towing a marine data acquisition system. It should be understood that this description is not intended to limit the invention. On the contrary, the exemplary embodiments are intended to cover alternatives, modifications and equivalents, which are included in the spirit and scope of the invention as defined by the appended claims. Further, in the detailed description of the exemplary embodiments, numerous specific details are set forth in order to provide a comprehensive understanding of the claimed invention. However, one skilled in the art would understand that various embodiments may be practiced without such specific details.

[0034] Although the features and elements of the present exemplary embodiments are described in the embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the embodiments or in various combinations with or without other features and elements disclosed herein.

[0035] This written description uses examples of the subject matter disclosed to enable any person skilled in the art to practice the same, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the subject matter is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims.

Claims

1. A deflector (350, 400, 500) configured to be attached to a cable (320) towed by a vessel (310) and configured to connect to a streamer (340) or a source (330) for a marine survey, the deflector comprising:

a wing body (410, 420, 510, 520) including a first part (410, 510) joined to a second part (420, 520) to form a swept-back-wing shape, the first part and the second part being substantially coplanar,
wherein

a first straight line stretching along at least a portion of a front edge (412, 512) of the first part makes a first angle (α_1) with a second straight line stretching along at least a portion of a front edge (422, 522) of the second part,
a third straight line stretching along at least a portion of a trailing edge (414, 514) of the first part makes a second angle (α_2) with a fourth straight line stretching along at least a portion of a trailing edge (424, 524) of the second part, the first angle and the second angle being non-zero angles,
characterized in that the deflector further comprises

a first ballast body located at an end of the first part opposite to the joining axis; and
a second ballast body located at an end of the second part opposite to the joining axis,
wherein

the first ballast body and the second ballast body have a shape configured to have low fluid friction when the body moves substantially parallel to the joining axis, and
the first ballast body is lighter than the second ballast body.

2. The deflector of claim 1, wherein the first angle and the second angle are substantially equal.

3. The deflector of claim 1, wherein
the portion of the front edge of the first part along which the first straight line stretches is longer than half of the front edge of the first part,
the portion of the front edge of the second part along which the second straight line stretches is longer than half of the front edge of the second part,
the portion of the trailing edge of the first part along which the third straight line stretches is longer than half of the trailing edge of the first part, and
the portion of the trailing edge of the second part along which the fourth straight line stretches is longer than half of the trailing edge of the second part.

4. The deflector of claim 1, wherein
the portion of the front edge of the first part along which the first straight line stretches and the portion of the front edge of the second part along which the second straight line stretches are connected via a first curved portion, and
the portion of the trailing edge of the first part along which the third straight line stretches and the portion of the trailing edge of the second part along which the fourth straight line stretches are connected via a second curved portion.

5. The deflector of claim 4, wherein the first curved portion is an arc of a circle having a first radius and the second curved portion is an arc of a circle having a second radius.

6. The deflector of claim 5, wherein the second radius is smaller than the first radius.

7. The deflector of claim 1, wherein the first angle is between 15º and 25º.

8. The deflector of claim 1, wherein the portion of the front edge of the first part, the portion of the front edge of the second part, the portion of the trailing edge of the first part, and the portion of the trailing edge of the second part, along which the first line, the second line, the third line and the fourth line respectively stretch, extend at least 10% of a length of the first part or of the second part, respectively.

9. The deflector of claim 1, wherein:
the first ballast body weighs between 10% and 35% of the second ballast body, and/or
the deflector is neutrally buoyant and the ballast is about 40% of the deflector's weight..

10. The deflector of claim 1, wherein the first part has a first slot extending from an end where the first part is joined to the second part toward an opposite end of the first part, and the second part has a second slot extending from an end where the second part is joined to the first part to an opposite end of the second part.

11. A marine data acquisition system (300), comprising:

towing cables (320) configured to be deployed according to a predetermined geometry behind a towing vessel (310) and configured to connect to a streamer (340) or a source (330); and
at least one deflector (350, 400, 500) according to claim 1 attached to one of the towing cables (320).

12. The marine data acquisition system of claim 11, wherein at least one of the following conditions is met:

(A) the first angle and the second angle are substantially equal;
(B) the first angle is between 15º and 25º;
(C) the at least one wing further has a first ballast body located at an end of the first part opposite to another end thereof where the first part is connected to the second part; and a second ballast body located at an end of the second part opposite to another end thereof where the second part is connected to the first part, wherein the first ballast body and the second ballast body have a shape configured to have low fluid friction when the wing body moves substantially parallel to the axis, and the first ballast body is lighter than the second ballast body.

13. The marine data acquisition system of claim 11, wherein the wing is a V-full wing.

14. The marine data acquisition system of claim 11, wherein
the portion of the front edge of the first part along which the first straight line stretches and the portion of the front edge of the second part along which the second straight line stretches are connected via a first curved portion, and
the portion of the trailing edge of the first part along which the third straight line stretches and the portion of the trailing edge of the second part along which the fourth straight line stretches are connected via a second curved portion.

15. A method (800) of controlling position of one or more components of a marine data acquisition system, the method comprising:

attaching (S810) a deflector according to claim 1 to a towing cable configured to be towed behind a vessel; and
deploying (S820) the towing cable behind the vessel according to a predetermined marine data acquisition geometry.

Patentansprüche

1. Deflektor (350, 400, 500), der konfiguriert ist, um an ein Kabel (320) befestigt zu sein, das von einem Schiff (310) geschleppt wird, und konfiguriert ist, um mit einen Streamer (340) oder eine Quelle (330) für eine Marineüberwachung verbunden zu sein,

einen Flügelkörper, (410, 420, 510, 520), darin eingeschlossen einen ersten Teil (410, 510), der mit einem zweiten Teil (420, 520) verbunden ist, um eine Pfeilflügelform zu bilden, wobei der erste Teil und der zweite Teil im Wesentlichen koplanar sind,
wobei
eine erste gerade Linie, die sich entlang mindestens einem Abschnitt einer vorderen Kante (412, 512) des ersten Teils ausdehnt, einen ersten Winkel (α_1) mit einer zweiten geraden Linie ergibt, die sich entlang mindestens einem Abschnitt einer vorderen Kante (422, 522) des zweiten Teils ausdehnt,
eine dritte gerade Linie, die sich entlang mindestens einem Abschnitt einer hinteren Kante (414, 514) des ersten Teils ausdehnt, einen zweiten Winkel (α_2) mit einer vierten geraden Linie ergibt, die sich entlang mindestens einem Abschnitt einer Hinteren Kante (424, 524) des zweiten Teils ausdehnt, wobei der erste Winkel und der zweite Winkel Nicht-Nullwinkel sind,
dadurch gekennzeichnet, dass der Deflektor weiter Folgendes umfasst:

einen ersten Ballastkörper, der an einem Ende des ersten Teils gegenüber der Verbindungsachse angeordnet ist; und
einen zweiten Ballastkörper, der an einem Ende des zweiten Teils gegenüber der Verbindungsachse angeordnet ist,

wobei
der erste Ballastkörper und der zweite Ballastkörper eine Form aufweisen, die konfiguriert ist, um eine niedrige Flüssigkeitsreibung aufzuweisen, wenn sich der Körper im Wesentlichen parallel zur Verbindungsachse bewegt, und
der erste Ballastkörper leichter als der zweite Ballastkörper ist.

2. Deflektor nach Anspruch 1, wobei der erste Winkel und der zweite Winkel im Wesentlichen gleich sind.

3. Deflektor nach Anspruch 1, wobei

der Abschnitt der vorderen Kante des ersten Teils, entlang dessen sich die erste gerade Linie ausdehnt, länger als die Hälfte der vorderen Kante des ersten Teils ist,
der Abschnitt der vorderen Kante des zweiten Teils, entlang dessen sich die zweite gerade Linie ausbreitet, länger als die Hälfte der vorderen Kante des zweiten Teils ist,
der Abschnitt der hinteren Kante des ersten Teil, entlang dessen sich die dritte gerade Linie ausbreitet, länger als die Hälfte der hinteren Kante des ersten Teils ist, und
der Abschnitt der hinteren Kante des zweiten Teils, entlang dessen sich die dritte gerade Linie ausbreitet, länger als die Hälfte der hinteren Kante des zweiten Teils ist.

4. Deflektor nach Anspruch 1, wobei

der Abschnitt der vorderen Kante des ersten Teils, entlang dessen sich die erste gerade Linie ausbreitet, und der Abschnitt der vorderen Kante des zweiten Teils, entlang dessen sich die zweite gerade Linie ausbreitet, über einen ersten gekrümmten Abschnitt verbunden sind, und der Abschnitt der hinteren Kante des ersten Teils, entlang dessen sich die dritte gerade Linie ausbreitet, der Abschnitt der Hinteren Kante des zweiten Teils, entlang dessen sich die dritte gerade Linie ausbreitet, über einen zweiten gekrümmten Abschnitt verbunden sind.

5. Deflektor nach Anspruch 4, wobeider erste gekrümmte Abschnitt ein Bogen eines Kreises ist, der einen ersten Radius aufweist, und der zweite gekrümmte Abschnitt ein Bogen eines Kreises ist, der einen zweiten Radius aufweist.

6. Deflektor nach Anspruch 5, wobei der zweite Radius kleiner als der erste Radius ist.

7. Deflektor nach Anspruch 1, wobei der erste Winkel zwischen 15º und 25º liegt.

8. Deflektor nach Anspruch 1, wobeider Abschnitt der Vorderen Kante des ersten Teils, der Abschnitt der Vorderen Kante des zweiten Teils, der Abschnitt der Hinteren Kante des ersten Teils, und der Abschnitt der Hinteren Kante des zweiten Teils, entlang denen sich die erste Linie, die zweite Linie, die dritte Linie

bzw. die vierte Linie ausbreiten, mindestens 10 % einer Länge des ersten Teile bzw. des zweiten Teils einnehmen.

9. Deflektor nach Anspruch 1, wobei

der erste Ballastkörper zwischen 10 % und 35 % des zweiten Ballastkörpers wiegt, und/oder
der Deflektor natürlicherweise schwimmt und der Ballast ungefähr 40 % des Gewichts des Deflektors ausmacht.

10. Deflektor nach Anspruch 1, wobeider erste Teil einen ersten Schlitz aufweist, der sich von einem Ende erstreckt, an dem der erste Teil mit dem zweiten Teil gegen ein gegenüber liegendes Ende des ersten Teils verbunden ist, und wobei der zweite Teil einen zweiten Schlitz aufweist, der sich von einem Ende erstreckt, an dem der zweite Teil mit dem ersten Teil gegen ein gegenüber liegendes Ende des zweiten Teils verbunden ist.

11. Marinedatenerfassungssystem (300), umfassend:

Schleppkabel (320), die konfiguriert sind, um gemäß einer vorbestimmten Geometrie hinter einem Schleppschiff (310) eingesetzt zu werden, und die konfiguriert sind, um mit einem Streamer (340) oder einer Quelle (330) verbunden zu werden; und
mindestens einen Deflektor (350, 400, 500) nach Anspruch 1, der an eines der Schleppkabel (320) befestigt ist.

12. Marinedatenerfassungssystem nach Anspruch 11, wobei mindestens eine der folgenden Bedingungen gegeben ist:

(A) der erste Winkel und der zweite Winkel sind im Wesentlichen gleich;
(B) der erste Winkel liegt zwischen 15º und 25º;
(C) der mindestens ein Flügel weist weiter einen Ballastkörper auf, der sich an einem Ende des ersten Teils gegenüber einem anderen Ende davon befindet,an dem der erste Teil mit dem zweiten Teil verbunden ist;und einen zweiten Ballastkörper, der sich an einem Ende des zweiten Teils gegenüber einem anderen Ende davon befindet,an dem der zweite Teil mit dem ersten Teil verbunden ist, wobei der erste Ballastkörper und der zweite Ballastkörper eine Form aufweisen, die konfiguriert ist, um eine niedrige Flüssigkeitsreibung aufzuweisen, wenn sich der Flügelkörper im Wesentlichen parallel zur Achse bewegt und der erste Ballastkörper leichter als der zweite Ballastkörper ist.

13. Marinedatenerfassungssystem nach Anspruch 11, wobei der Flügel ein vollständiger V-Flügel ist.

14. Marinedatenerfassungssystem nach Anspruch 11, wobei

der Abschnitt der Vorderen Kante des ersten Teils, entlang dem sich die erste gerade Linie ausbreitet, und der Abschnitt der Vorderen Kante des zweiten Teils, entlang dem sich die zweite gerade Linie ausbreitet, über einen ersten gekrümmten Abschnitt verbunden sind, und
der Abschnitt der Hinteren Kante des ersten Teils, entlang dem sich die dritte gerade Linie ausbreitet, und der Abschnitt der Hinteren Kante des zweiten Teils, entlang dem sich die vierte gerade Linie ausbreitet, über einen zweiten gekrümmten Abschnitt verbunden sind.

15. Verfahren (800) zum Steuern der Position eines oder mehrerer Bestandteile eines Marinedatenerfassungssystem, wobei das Verfahren Folgendes umfasst:

Befestigen (S810) eines Deflektors nach Anspruch 1 an ein Schleppkabel, das konfiguriert ist, um hinter einem Schiff geschleppt zu werden; und
Einsetzen (S820) des Schleppkabels hinter dem Schiff gemäß einer vorbestimmten Marinedatenerfassungsgeometrie.

Revendications

1. Déflecteur (350, 400, 500) configuré pour être fixé à un câble (320) tracté par un navire (310) et configuré pour être relié à une flûte sismique (340) ou à une source (330) pour un levé marin, le déflecteur comprenant :

un corps d'aile (410, 420, 510, 520) incluant une première partie (410, 510) assemblée à une seconde partie (420, 520) pour prendre une forme d'aile en flèche, la première partie et la seconde partie étant sensiblement coplanaires,
dans lequel
une première ligne droite s'étirant le long d'au moins une section d'un bord avant (412, 512) de la première partie forme un premier angle (α_1) avec une deuxième ligne droite s'étirant le long d'au moins une section d'un bord avant (422, 522) de la seconde partie,
une troisième ligne droite s'étirant le long d'au moins une section d'un bord de fuite (414, 514) de la première partie forme un second angle (α_2) avec une quatrième ligne droite s'étirant le long d'au moins une section d'un bord de fuite (424, 524) de la seconde partie, le premier angle et le

deuxième angle étant des angles non nuls,
caractérisé en ce que le déflecteur comprend en outre
un premier corps de ballast situé à une extrémité de la première partie opposée à l'axe d'assemblage ; et
un second corps de ballast situé à une extrémité de la seconde partie opposée à l'axe d'assemblage,
dans lequel
le premier corps de ballast et le second corps de ballast ont une forme configurée pour présenter un faible frottement fluide lorsque le corps se déplace sensiblement parallèlement à l'axe d'assemblage, et
le premier corps de ballast est plus léger que le second corps de ballast.

2. Déflecteur selon la revendication 1, dans lequel le premier angle et le second angle sont sensiblement égaux.

3. Déflecteur selon la revendication 1, dans lequel
la section du bord avant de la première partie le long de laquelle s'étend la première ligne droite est plus longue que la moitié du bord avant de la première partie,
la section du bord avant de la seconde partie le long de laquelle s'étend la deuxième ligne droite est plus longue que la moitié du bord avant de la seconde partie,
la section du bord de fuite de la première partie le long de laquelle s'étend la troisième ligne droite est plus longue que la moitié du bord de fuite de la première partie, et
la section du bord de fuite de la seconde partie le long de laquelle s'étend la quatrième ligne droite est plus longue que la moitié du bord de fuite de la seconde partie.

4. Déflecteur selon la revendication 1, dans lequel
la section du bord avant de la première partie le long de laquelle s'étend la première ligne droite et la section du bord avant de la seconde partie le long de laquelle s'étend la deuxième ligne droite sont reliées via une première section incurvée, et
la section du bord de fuite de la première partie le long de laquelle s'étend la troisième ligne droite et la section du bord de fuite de la seconde partie le long de laquelle s'étend la quatrième ligne droite sont reliées via une seconde section incurvée.

5. Déflecteur selon la revendication 4, dans lequel la première section incurvée est un arc d'un cercle ayant un premier rayon et la seconde section incurvée est un arc d'un cercle ayant un second rayon.

6. Déflecteur selon la revendication 5, dans lequel le second rayon est plus petit que le premier rayon.

7. Déflecteur selon la revendication 1, dans lequel le premier angle est compris entre 15° et 25°.

8. Déflecteur selon la revendication 1, dans lequel la section du bord avant de la première partie, la section du bord avant de la seconde partie, la section du bord de fuite de la première partie, et la section du bord de fuite de la seconde partie, le long desquelles s'étendent respectivement la première ligne, la deuxième ligne, la troisième ligne et la quatrième ligne, prolongent d'au moins 10 % une longueur de la première partie ou de la seconde partie, respectivement.

9. Déflecteur selon la revendication 1, dans lequel
le premier corps de ballast pèse entre 10 % et 35 % du second corps de ballast, et/ou
le déflecteur a une flottabilité neutre et le ballast représente environ 40 % du poids du déflecteur.

10. Déflecteur selon la revendication 1, dans lequel la première partie comporte une première fente s'étendant d'une extrémité où la première partie est assemblée à la seconde partie vers une extrémité opposée de la première partie, et la seconde partie comporte une seconde fente s'étendant d'une extrémité où la seconde partie est assemblée à la première partie d'une extrémité opposée de la seconde partie.

11. Système d'acquisition de données en mer (300), comprenant :

des câbles de remorquage (320) configurés pour être déployés selon une géométrie prédéterminée derrière un navire de remorquage (310) et configurés pour être reliés à une flûte sismique (340) ou une source (330) ; et
au moins un déflecteur (350, 400, 500) selon la revendication 1 fixé à l'un des câbles de remorquage (320).

12. Système d'acquisition de données en mer selon la revendication 11, dans lequel au moins l'une des conditions suivantes est remplie :

(A) le premier angle et le second angle sont sensiblement égaux ;
(B) le premier angle est compris entre 15° et 25° ;
(C) l'au moins une aile comporte en outre un premier corps de ballast situé à une extrémité de la première partie opposée à une autre extrémité de celle-ci où la première partie est reliée à la seconde partie ; et un second corps de ballast situé à une extrémité de la seconde partie

opposée à une autre extrémité de celle-ci où la seconde partie est reliée à la première partie, dans lequel le premier corps de ballast et le second corps de ballast ont une forme configurée pour avoir un faible frottement fluide lorsque le corps d'aile se déplace sensiblement parallèlement à l'axe, et le premier corps de ballast est plus léger que le second corps de ballast.

13. Système d'acquisition de données en mer selon la revendication 11, dans lequel l'aile est une aile complète en V.

14. Système d'acquisition de données en mer selon la revendication 11, dans lequel
la section du bord avant de la première partie le long de laquelle s'étend la première ligne droite et la section du bord avant de la seconde partie le long de laquelle s'étend la deuxième ligne droite sont reliées via une première section incurvée, et
la section du bord de fuite de la première partie le long de laquelle s'étend la troisième ligne droite et la section du bord de fuite de la seconde partie le long de laquelle s'étend la quatrième ligne droite sont reliées via une seconde section incurvée.

15. Procédé (800) de contrôle de position d'un ou plusieurs composants d'un système d'acquisition de données en mer, le procédé comprenant :

la fixation (S810) d'un déflecteur selon la revendication 1 à un câble de remorquage configuré pour être tracté par un navire ; et
le déploiement (S820) du câble de remorquage derrière le navire selon une géométrie d'acquisition de données en mer prédéterminée.

Figure 1

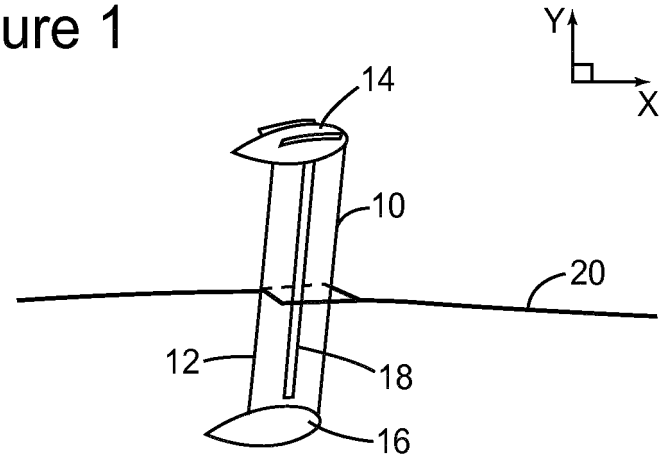

Figure 2A

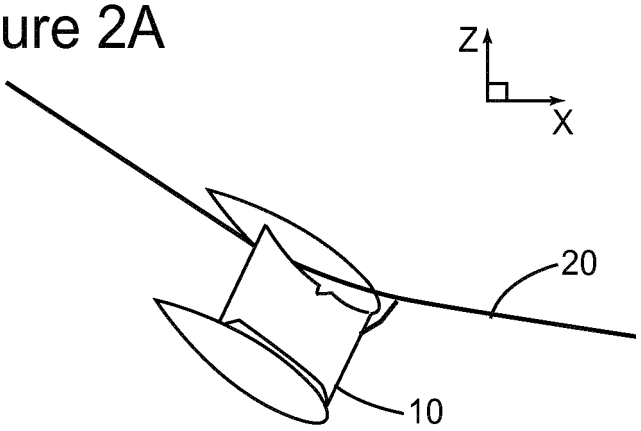

Figure 2B

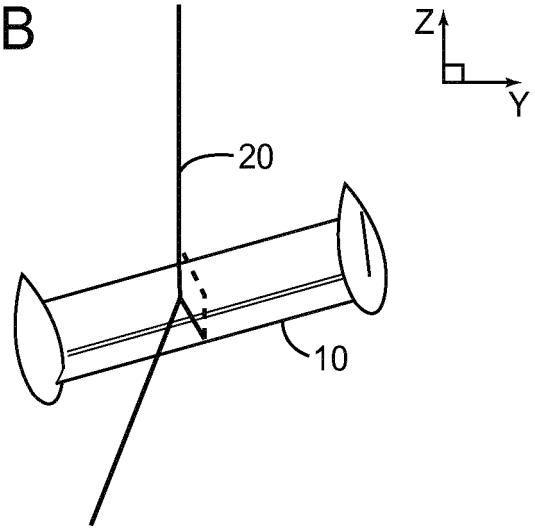

Figure 3

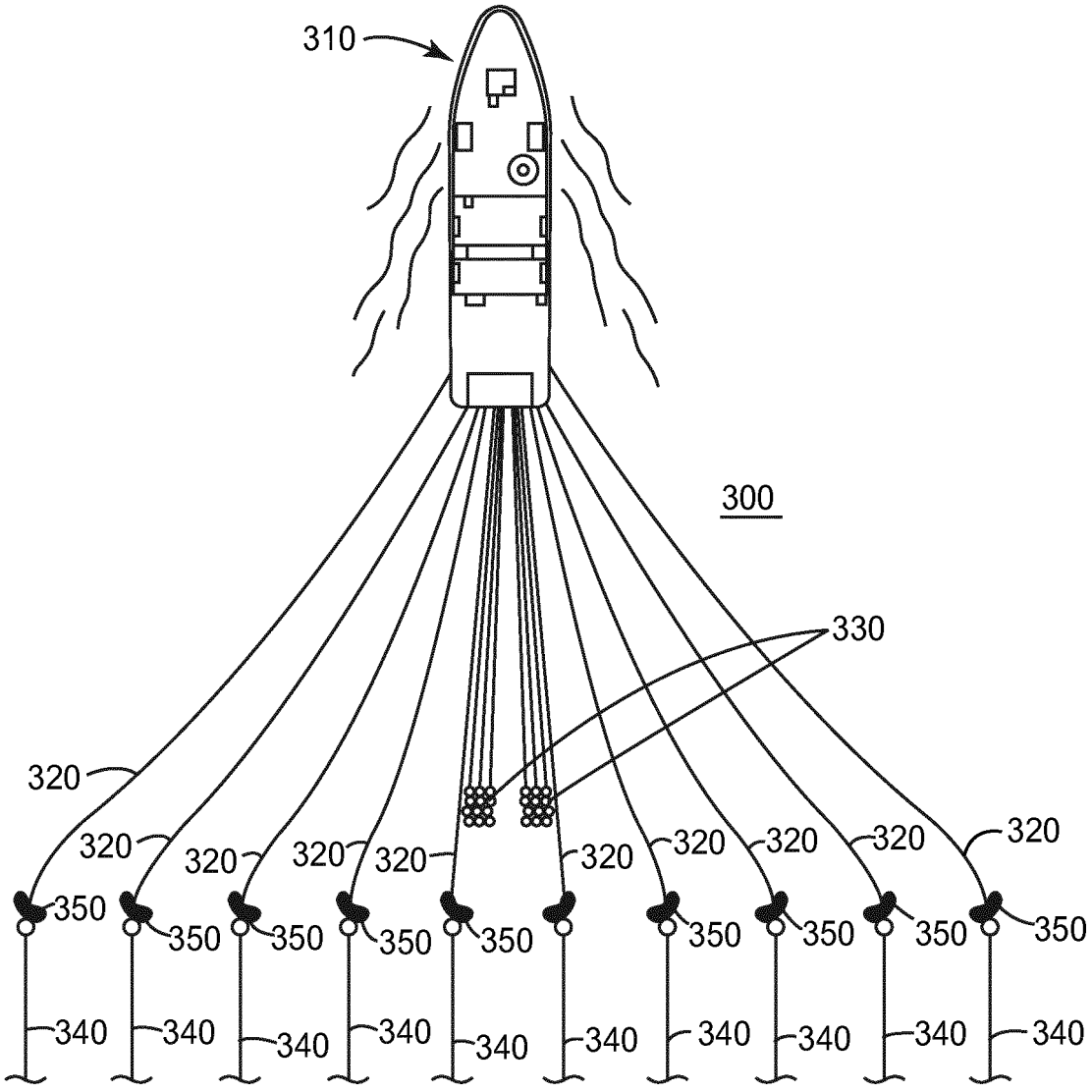
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Figure 4

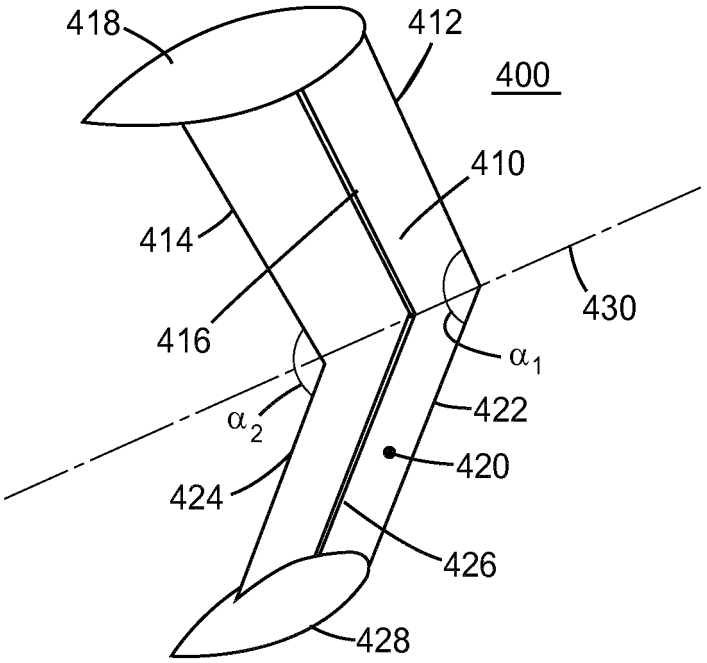


Figure 5

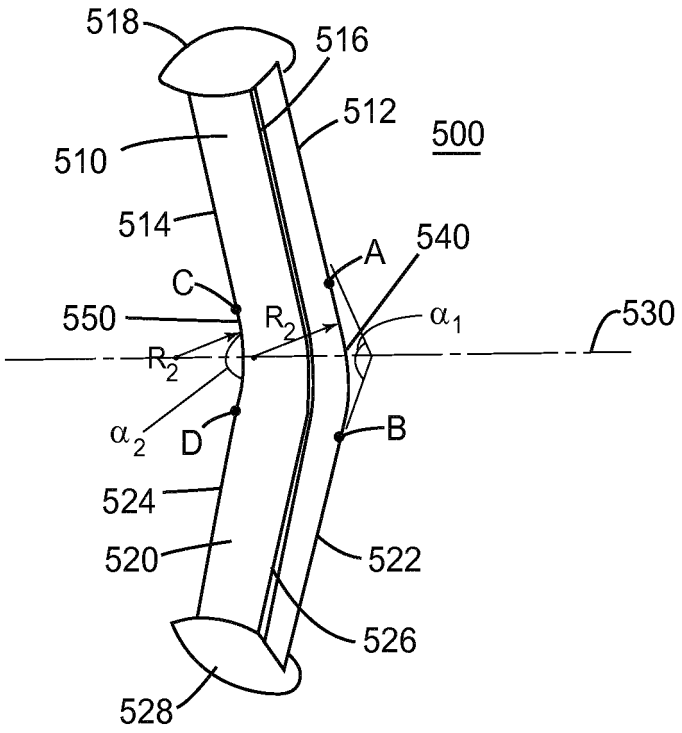


Figure 6

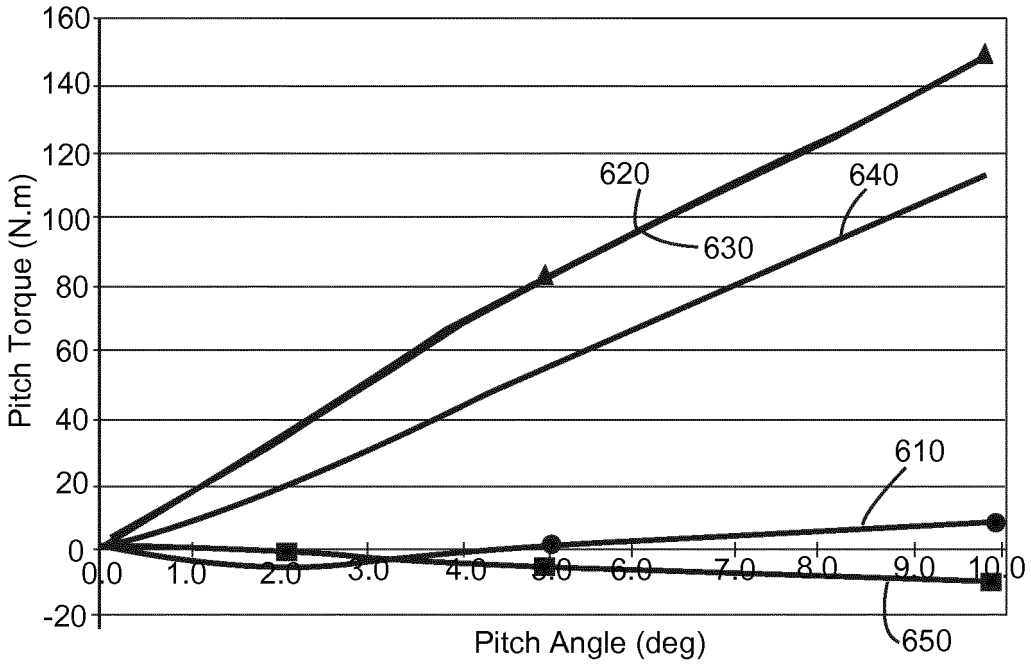


Figure 7

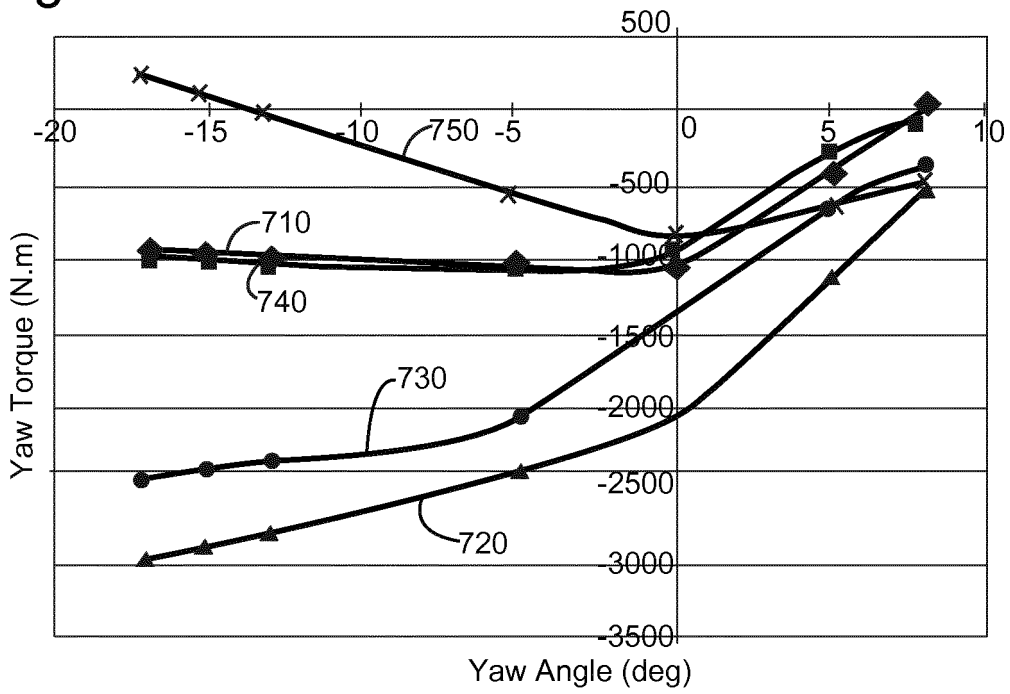
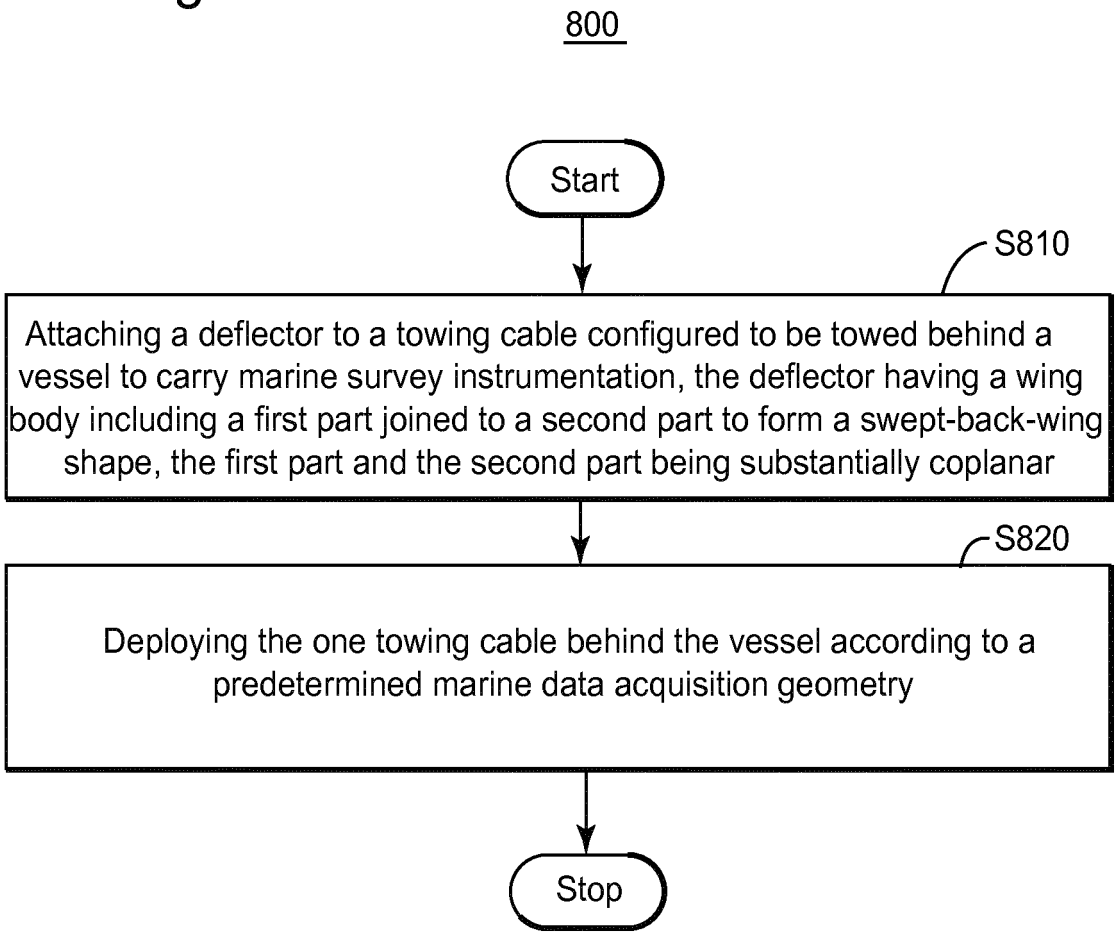


Figure 8


800
Start
S810
Attaching a deflector to a towing cable configured to be towed behind a vessel to carry marine survey instrumentation, the deflector having a wing body including a first part joined to a second part to form a swept-back-wing shape, the first part and the second part being substantially coplanar
S820
Deploying the one towing cable behind the vessel according to a predetermined marine data acquisition geometry
Stop

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 6820568 B **[0003]**
- US 5000110 A **[0003]**
- US 2980052 A **[0003]**
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